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EFFECTS OF WEATHER AND HELPERS ON SURVIVAL OF NESTLING RED-COCKADED WOODPECKERS

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ABSTRACT.—Non-breeding adult Red-cockaded Woodpeckers (*Picoides borealis*), termed helpers, participate in many aspects of the nesting cycle, including feeding nestlings. Typically, groups that include helpers exhibit a higher nesting success and fledge more young than groups lacking helpers. We studied Red-cockaded Woodpeckers in the Ouachita National Forest in Arkansas in 1991 and 1992. In 1992, at the peak of the woodpecker nestling stage, eight of 10 unexpected deaths of nestlings older than six days posthatch occurred during 15 consecutive days of abnormally low temperatures (as low as 9°C) and elevated rainfall that reduced potential adult woodpecker foraging time by 26%. Altogether, during the abnormal weather of 1992, eight of nine nestlings survived in groups with helpers, whereas only seven of 14 survived in groups lacking helpers. In both years, woodpecker groups with helpers suffered fewer losses and fledged more young per nesting attempt ($P = <0.001$). *Received 21 Dec. 1992, accepted 1 May 1993.*

Insufficient food contributes to avian mortality during abnormal weather (Gessaman and Worthen 1982). Insectivorous birds especially are vulnerable to fluctuations of food supplies because departures from climatic norms can alter insect activities (Wigglesworth 1972, Bursell 1974), making insects unavailable to birds (Hays 1969, Zumeta and Holmes 1978, Smith 1982). We examined mortality among nestling Red-cockaded Woodpeckers (*Picoides borealis*) during a period of cool, rainy weather in 1992. Weather-mediated events apparently depressed insect activity and reduced foraging opportunities for adult woodpeckers. Presence of helpers in this cooperatively breeding species was associated with improved nestling survival.

STUDY AREA AND METHODS

In 1991 and 1992, 15 clusters of cavity trees of Red-cockaded Woodpeckers were monitored in the Ouachita National Forest (Ouachita NF) of west-central Arkansas. The cavity trees were mature shortleaf pines (*Pinus echinata*) occurring in older second growth stands that also included hardwoods, especially oaks (*Quercus* spp.). Most stands had open un-

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derstories and midstories as a result of U.S. Forest Service management practices, including prescribed burning and reduction of pine and hardwood midstories.

All nest cavity trees of Red-cockaded Woodpeckers were climbed and cavities inspected with a light and mirror 1–2 times each week during the nesting season. Nests were monitored from 23 April to 24 July 1991 and from 12 April to 24 July 1992. Prior to the nesting season, roost cavities were monitored to determine the composition of each woodpecker group. In addition to the male-female pair, three groups contained 1–2 additional adults that also roosted in the cluster. These birds were presumedly helpers (sensu Ligon 1970).

Frequent checking of nests with eggs allowed us to determine probable laying dates. Based upon an average of 10–11 days for incubation (Ligon 1970), backdating allowed determination of probable date when the initial 1–2 eggs were laid. Nests were inspected within 1–3 days after expected hatching. Optimal banding time is within days 5–9, prior to the time when young birds open their eyes. Nooses were used to remove nestlings from cavities (Jackson 1982), and each nestling was banded with a metal band from the U.S. Fish and Wildlife Service. All adult woodpeckers had been banded prior to the nesting season with combinations of metal and colored plastic bands to allow field identification of individual birds. When dead or missing nestlings were discovered, an estimated date of death was calculated by starting with the number of days that had elapsed from the last cavity check and assigning the midpoint as the date of death or disappearance. An expected fledging date was also calculated. It was assumed that the birds had fledged if older nestlings were still present in the nest cavity 1–2 days prior to the expected fledging date.

The primary source of weather data for west-central Arkansas was the National Weather Service at Fort Smith, Arkansas, approximately 60 km north of our study area. Monthly summaries of the local climatological data (May and June), including preliminary local climatological data (NOAA 1992), were consulted. We also examined local weather data from Waldron, Arkansas, located approximately 15 km from our study areas (NOAA 1992).

RESULTS

In 1991 and 1992, all nesting attempts (N = 27) of Red-cockaded Woodpeckers in the Ouachita NF were monitored. After the initial brood reduction that is typical of this species (Ligon 1970, Lennartz et al. 1987), 47 nestlings approximately six days or older remained in 21 nests (mean initial brood size was 2.24 nestlings). Overall, out of the 47 nestlings that survived initial brood reduction in the Ouachita NF, 31 fledged (66%). Eighteen of the 27 nesting attempts (67%) were successful in fledging at least one young.

In 1991, 75% (18 out of 24) of the older (over six days in age) nestlings in the Ouachita NF survived, compared to 56% (13 of 23) in 1992. The overall difference in survival was associated with presence or absence of helpers in the woodpecker groups (Table 1).

In the Ouachita NF in 1992, a disproportionate number (eight of 10) of late losses of nestlings occurred during 15 consecutive days of abnormally low temperatures (Fig. 1) and a high frequency of rain showers (Fig. 2). Temperatures in 1992 remained below 30-year average daily temperatures (and below 1991 temperatures) continuously from 24 May to 7 June (NOAA 1991, 1992), a period that coincided with the peak abun-

TABLE 1

EFFECT OF HELPERS ON NUMBERS OF FLEDGLING RED-COCKADED WOODPECKERS PER NESTING ATTEMPT, OUACHITA NATIONAL FOREST, ARKANSAS, 1991 AND 1992

		Number of fledglings per nest			
		0	1	2	3
Nests without helpers	(21)[a]	9	8	4	0
Nests with helpers	(6)[a]	0	0	3	3

[a] Numbers of nesting attempts included in analysis.

dance of nestling Red-cockaded Woodpeckers (Fig. 1). Average daily temperature (average of low–high temperatures for the day) ranged from 11.7 to 21.7°C, with the lowest reading on 28 May, when the temperature dipped to 11.1°C below the 30-year average daily temperature. Temperatures ranged from 5 to 11.1°C ($\bar{x}$ = 7.1°C) below the 30 year average from 25 to 30 May, with a low temperature of 8.9°C on 30 May.

Precipitation data from Fort Smith, Arkansas, showed that rain or traces

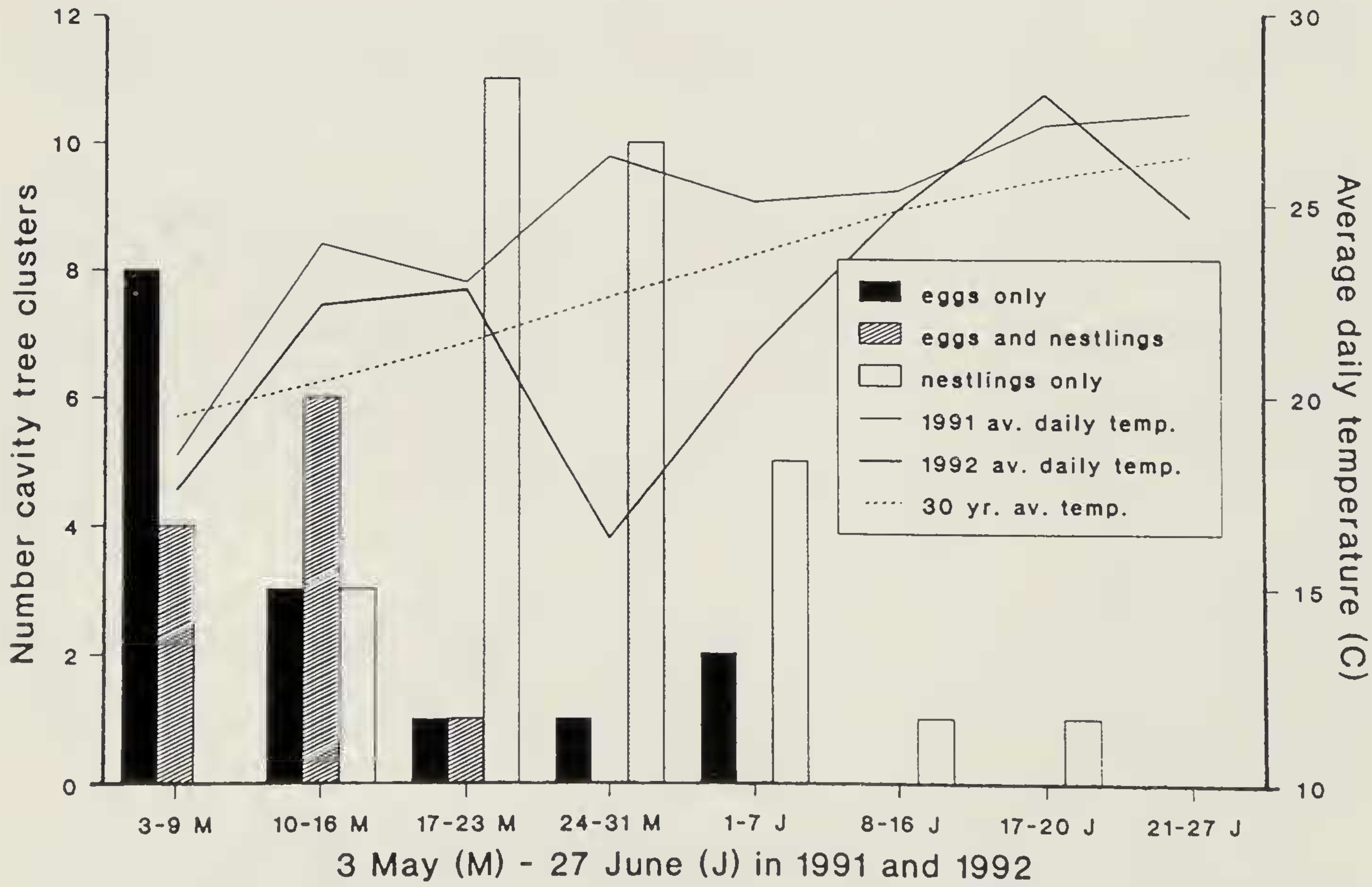

FIG. 1. Relation of average daily temperature and nesting stage of Red-cockaded Woodpeckers in the Ouachita NF in Arkansas in 1991 and 1992. Average daily temperature includes 1991, 1992, and the 30 year average. Daily temperature shown is an average of high and low temperatures for the day (therefore, daily highs and lows may be more extreme than those shown in Fig. 1).

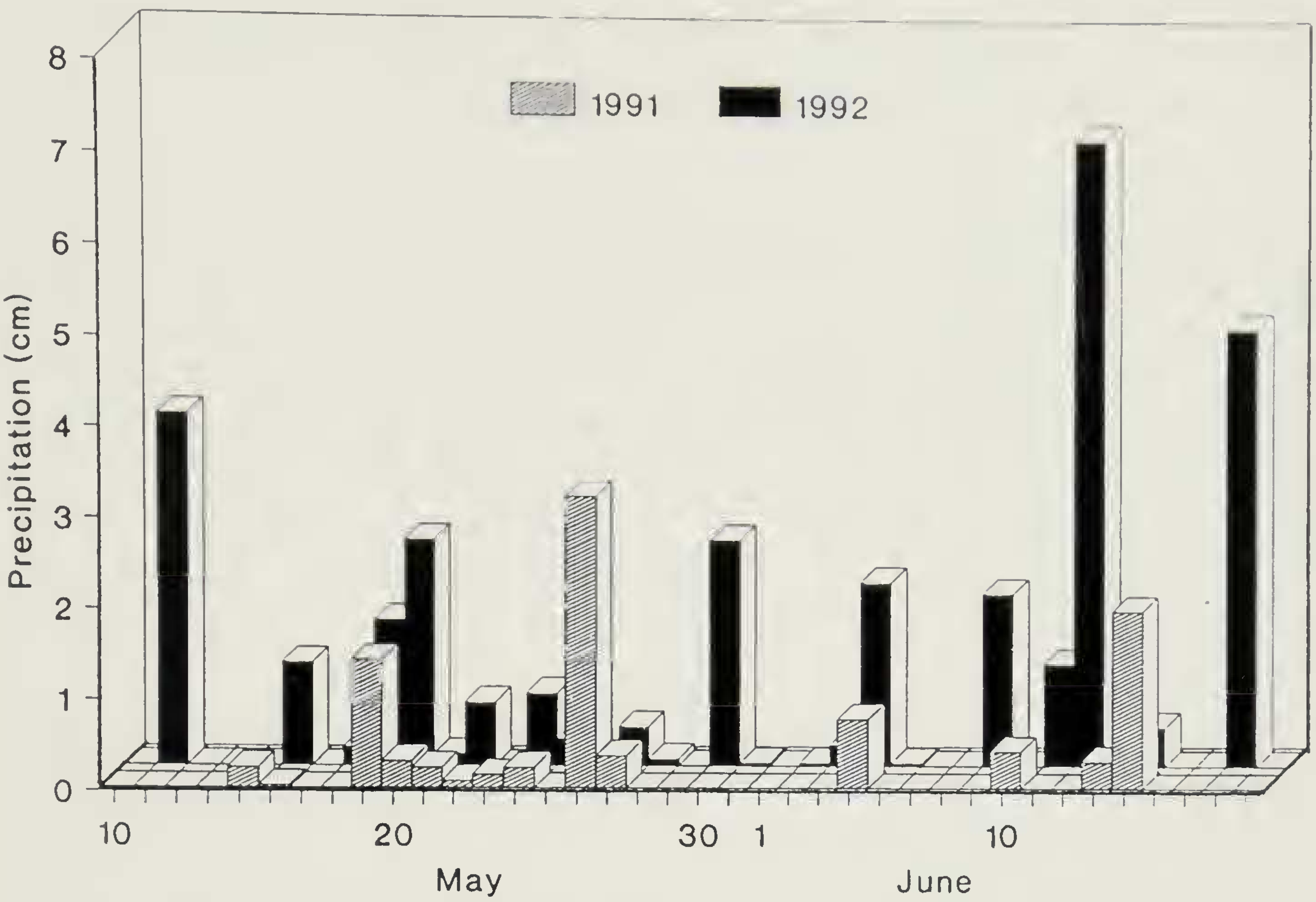

FIG. 2. Daily precipitation recorded at Fort Smith, Arkansas, during the peak of the nesting season for Red-cockaded Woodpeckers in 1991 and 1992. Trace precipitation arbitrarily was estimated at 0.001 cm.

of rain fell during 12 of 15 days of the below normal temperatures between 24 May and 7 June 1992 (NOAA 1992). On 25 May 1992, rain totaling 0.4 cm fell during nine h between 06:00 and 18:00 h CST. Only traces of moisture were recorded for 26 and 27 May, but 2.49 cm fell on 28 May during an all day storm. In 1991, by comparison, rain or traces of rain fell on only five days of the same 15-day period, and temperatures frequently exceeded the 30-year average for the area during the same period (Fig. 1).

In 1992, dead nestlings (N = 8) were found in six nests between 26 May and 2 June, and a ninth nestling, aged 19 days, was missing from its nest. Two of 14 broods, involving four nestlings aged 16–24 days, failed completely during this period. Altogether, six broods suffered unexpected losses of 1–2 nestlings (N = 8) aged 16–24 days.

In the Ouachita NF, woodpecker groups with helpers suffered fewer losses and fledged more young per nesting attempt in both years ($z = 4.52$, $P = <0.001$, one-tailed test, Wilcoxon-Mann-Whitney test). In 1991 and 1992, no nest attempt by groups with helpers (N = 6) was unsuccessful in fledging young, and all nests that totally failed (N = 13) involved groups without helpers (Table 1). Finally, during the cool rainy weather of 1992, eight of nine nestlings survived in groups with helpers, whereas only seven of 14 nestlings survived in groups without helpers.

DISCUSSION

The effect of helpers on nestling survival in the Ouachita NF supports findings from elsewhere in the range of this woodpecker. Groups with helpers consistently fledge more young (Ligon 1970, Lennartz et al. 1987, Walters 1990). Helpers participate in many activities associated with nesting, including feeding the young (Ligon 1970, Lennartz and Harlow 1979). In South Carolina, the presence of helpers was associated with enhanced survival of nestlings, especially when the breeding female was inexperienced (Lennartz et al. 1987). In the Ouachita NF, it appears the presence of helpers buffered the negative affects of abnormal weather on nestling survival.

Red-cockaded Woodpeckers cease feeding during rainfall or inclement weather (Ligon 1970, Baker 1971, Beckett 1971, pers. obs.), and rain was frequent during the cool period of 1992. During the last week of May, rain was recorded during 26% (27 of 104) of the daylight hours between 07:00 and 19:00 h CST and sunshine was recorded during only 38% of total daylight hours (NOAA 1992). This contrasts sharply with 1991, when one hour was unavailable for foraging because of rain. The relatively light rainfall of 25 May 1992 may have had a negligible effect on the ability of adult woodpeckers to provision young, but the day-long downpour of 28 May came on the fifth day of cool weather (and it rained heavily at Waldron on the following day). The deaths of most nestlings came soon afterward, between 29 May and 2 June 1992.

In North Carolina, annual variation in reproduction of Red-cockaded Woodpeckers was potentially linked to environmental conditions, but no heavy losses directly related to weather were noted there (M. LaBranche, pers. comm.). In South Carolina, significant losses of eggs and young resulted from "nest colonies being flooded with rain during violent storms in June" (Teulings 1973).

Alternatives to weather as the chief contributing cause of these unexpected deaths have been considered and ruled out. Intraspecific conflicts for cavities involving Red-bellied Woodpeckers (*Melanerpes carolinus*) or southern flying squirrels (*Glaucomys volans*) during 1991–1992 were monitored also (Neal et al. 1992). No Red-cockaded Woodpecker nest cavity was usurped by other species during the period in which the nestling losses occurred (unpubl. data). Nestling deaths can also follow loss of one adult in groups unassisted by helpers (Lennartz et al. 1987), but both adult woodpeckers were present in all clusters of cavity trees throughout the nesting season. Predation losses were discounted because unpredated carcasses of dead nestlings were present in four nest cavities. No insecticides were used within the home ranges of these groups.

Nest cavities were checked on similar schedules in 1991 and 1992, but with a single exception (see below), no dead nestlings were found in cavities in 1991. Of six older nestlings (older than six days) lost in 1991, three were eaten by a black rat snake (*Elaphe o. obsoleta*) that was found during a cavity inspection (Neal et al. 1993). As a result of protecting woodpecker cavity trees from snake climbing (Withgott et al. 1993), no snake predation occurred in 1992. Even with the snake predation in 1991, 75% of older nestlings survived, compared to 56% in 1992. By accounting for snake predation in 1991 and the weather pattern of 1992, we calculated that the survival rate of nestlings in each year would have been similar to the higher values reported in North Carolina (Walters 1990).

While cavity use confers many benefits, including protection from weather extremes and enhanced ability to thermoregulate, the broods of cavity nesters are not immune to climatic extremes that affect food availability. Mortality may be high if food is scarce, particularly at older ages when nestlings need increased food (Short 1982). In 1976 in Finland, unseasonably low temperatures and almost continuous rain for two days (28 and 29 June) was followed on 29 and 30 June by deaths of nestlings in three species of cavity nesting birds (Pulliainen 1977). On the other hand, weather-related mortality of nestlings was infrequent among Acorn Woodpeckers (*Melanerpes formicivorus*), which store food (Koenig and Mumme 1987).

There is collateral evidence to support the hypothesis that woodpecker nestling deaths were caused by a shortage of food that adults would normally have provided to nestlings. The abnormal pattern of cool weather that affected the Ouachita NF extended throughout most of the central U.S. (Climate Analysis Center 1992). The starvation deaths of thousands of Purple Martins (*Progne subis*) coincided with the deaths of woodpecker nestlings in the same region (pers. obs.). Besides northwestern Arkansas, Purple Martins died over a wide area primarily west of Arkansas, with deaths of both nestlings and adults reported (Wright 1992). While Red-cockaded Woodpeckers are occasional aerial feeders (Beckett 1971), the typical arboreal insects upon which these woodpeckers feed (Beal 1911, Short 1982) must also have been affected.

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LITERATURE CITED

Baker, W. W. 1971. Progress report on life history studies of Red-cockaded Woodpeckers at Tall Timbers Research Station. Pp. 44–59 *in* Ecology and management of the Red-cockaded Woodpecker (R. L. Thompson, ed.). Bur. Sport Fish. and Wildl. and Tall Timbers Res. Sta., Tallahassee, Florida.

Beal, F. E. 1911. Food of woodpeckers of the United States. U.S.D.A., Biol. Surv. Bull. No. 37, Washington, D.C.

Beckett, T. 1971. A summary of Red-cockaded Woodpecker observations in South Carolina. Pp. 87–95 *in* Ecology and management of the Red-cockaded Woodpecker (R. L. Thompson, ed.). Bur. Sport Fish. and Wildl. and Tall Timbers Res. Sta., Tallahassee, Florida.

Bursell, E. 1974. Environmental aspects-temperature. Pp. 2–41 *in* The physiology of Insecta. Vol. 2. (M. Rockstein, ed.). 2nd edition. Academic Press, New York, New York.

Climate Analysis Center. 1992. Weekly Climate Bulletin 92/23, 6 June:2–3. Washington, D.C.

Gessaman, J. A. and G. L. Worthen. 1982. The effect of weather on avian mortality. Utah State Univ. Printing Services, Logan, Utah.

Hays, H. 1969. Differential survival among nestling Red-winged Blackbirds after a storm. Auk 86:563–564.

Jackson, J. A. 1982. Capturing woodpecker nestlings with a noose—a technique and its limitations. N.A. Bird Bander 7:90–92.

Koenig, W. D. and R. L. Mumme. 1987. Population ecology of the cooperatively breeding Acorn Woodpecker. Princeton Univ. Press, Princeton, New Jersey.

Lennartz, M. R. and R. F. Harlow. 1979. The role of parent and helper Red-cockaded Woodpeckers at the nest. Wilson Bull. 91:331–335.

———, R. G. Hooper, and R. F. Harlow. 1987. Sociality and cooperative breeding of red-cockaded woodpeckers, *Picoides borealis.* Behav. Ecol. Sociobiol. 20:77–88.

Ligon, J. D. 1970. Behavior and breeding biology of the Red-cockaded Woodpecker. Auk 87:255–278.

National Oceanic and Atmospheric Administration. 1991. Local climatological data, monthly summary (National Climatic Data Center for May–June at Fort Smith, Arkansas). Washington, D. C.

———. 1992. Local climatological data, monthly summary (National Climatic Data Center for May–June at Fort Smith, Arkansas). Washington, D.C.

Neal, J. C., W. G. Montague, and D. A. James. 1992. Sequential occupation of cavities by Red-cockaded Woodpeckers and Red-bellied Woodpeckers in the Ouachita National Forest. Proc. Ark. Acad. Sci. 46:105–108.

———, ———, and ———. 1993. Climbing by black rat snakes on cavity trees of Red-cockaded Woodpeckers. Wildl. Soc. Bull. 21:160–165.

Pulliainen, E. 1977. Habitat selection and breeding biology of box-nesting birds in north-eastern Finnish forest Lapland. Aquilo Ser. Zool. 17:7–22.

SHORT, L. L. 1982. Woodpeckers of the world. Mono. Ser. 4, Delaware Museum of Natural History, Greenville, Delaware.

SMITH, K. G. 1982. Drought-induced changes in avian community structure along a montane sere. Ecology 63:952–961.

TEULINGS, R. P. 1973. Southern Atlantic coast region. Am. Birds 27:856–859.

WALTERS, J. R. 1990. Red-cockaded Woodpeckers: a "primitive" cooperative breeder. Pp. 69–101 *in* Cooperative breeding in birds: long-term studies of ecology and behavior (P. B. Stacey and W. D. Koenig, eds.). Cambridge Univ. Press, Cambridge, England.

WIGGLESWORTH, V. B. 1972. The principles of insect physiology. 7th ed. Chapman and Hall, London, England.

WITHGOTT, J. H., J. C. NEAL, AND W. G. MONTAGUE. 1993. A technique to deter climbing by rat snakes on cavity trees of Red-cockaded Woodpeckers. *in* Red-cockaded Woodpecker Symposium III: species recovery, ecology and management (R. Costa, D. L. Kulhavy, and R. G. Hooper, eds.). Charleston, South Carolina (in press).

WRIGHT, H. F. 1992. Widespread losses of martin young in western portion of range. Nature Soc. News 27(7):1.

ZUMETA, D. AND R. T. HOLMES. 1978. Habitat shift and roadside mortality of Scarlet Tanagers during a cold, wet New England spring. Wilson Bull. 90:575–586.